

ART. IX.—*Notes on the Barometric Measurement of Heights.*

By PROFESSOR KERNOT, M.A., C.E.

[Read June 13, 1889.]

I propose at the present time to submit to the Society a few remarks on the above subject, in connection with the very full and interesting paper given by the Vice-President last month. In that paper the author expressed considerable doubt as to the accuracy of certain statements that had from time to time been made with reference to the high degree of precision with which differences of level can be obtained by means of ordinary aneroids, in the hands of observers whose time is limited, and who are not provided with the costly appliances to be found at a great national observatory. In this view he is certainly not singular, as several of the most experienced and skilful surveyors of my acquaintance have repeatedly made in my hearing very disparaging statements as to these instruments and their performances. Thus, it will be seen that there has been considerable difference of opinion. Some experienced and reliable surveyors speaking of the instrument as being capable of giving differences of level in average cases within five feet, or even less, of the truth; while others regard an error of 100 feet as not only possible, but even probable, under ordinary circumstances. To determine which of these two views is correct, is a matter of great importance from an engineering point of view. If the relative levels of points ten or twenty miles distant can be determined with a probable error of not more than ten, or even twenty feet, the location of roads, railways, and schemes of water supply will be greatly facilitated, as a few hours' work of a solitary observer with the aneroid will often serve, instead of several days' labour of a fully-equipped survey party.

I do not, of course, propose to dispense with accurate levelling in the final or detailed survey of the adopted line. It is in the preliminary investigation and comparison of various possible alternative routes that extreme accuracy is

not needed, while the speed and small cost of aneroid work are so advantageous.

Having taken, on several occasions, the optimistic view in this matter, I felt it desirable to submit some results justifying this opinion. The instruments with which the results I propose to quote were obtained, are the following :—

1. A small compensated aneroid supplied by Kilpatrick and Co., about fifteen years ago. It is a good instrument of its kind, and when tested at the Observatory under the air pump, showed great sensitiveness, the hand responding promptly to the smallest change of pressure. At the same time, I do not suppose it is better than many others that have been exposed for sale by Melbourne opticians.

2. A large open-faced aneroid, not compensated, with a five-inch dial, supplied by the same firm about twenty years ago. This was an exceedingly cheap instrument, but happens to be unusually sensitive, responding to a variation of pressure represented by $\frac{1}{200}$ th inch of mercury. This instrument I used many years ago in laying out contour lines on the Geelong waterworks, and found the lines so laid out, when subsequently tested by levelling, to be almost always within three feet of the right level. I should add that I was aided by accurate level marks about fifty feet lower down the slope.

3. A new Watkin aneroid, supplied to the University by Kilpatrick and Co., jewelled and compensated, and having a scale so open that a movement of the index corresponding to $\frac{1}{1000}$ th inch of mercury is visible. This instrument is marked No. 161 on the dial.

4. An aneroid barograph marked Kilpatrick and Co., Melbourne, and purchased last year. This instrument keeps a constant record of the pressure of the atmosphere, and as far as I have tested it has worked satisfactorily.

The first experiment that I wish to describe was made about twelve years ago. Four readings were taken with instrument No. 1, on the crest of the dam of the Pipehead reservoir, Geelong Water Works. These readings were taken at intervals of three or four hours, and were compared with simultaneous readings on the mercurial barograph at the Government Observatory, corrections for temperature and for instrumental errors being applied. The true difference of level by levelling was 760 feet, and the distance about forty miles, the intervening country being nearly level and generally devoid of trees. The four

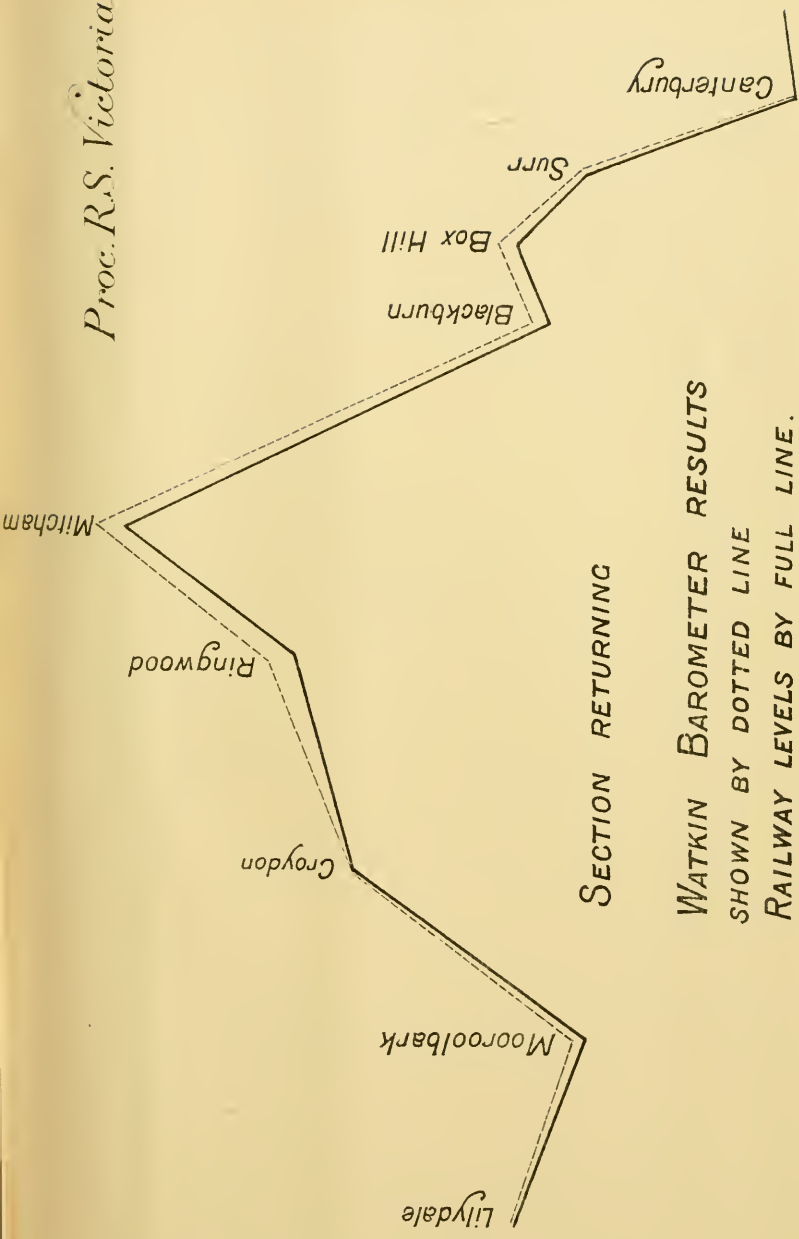
determinations by barometer were all too low, the best being four feet out, the worst eight feet, and the average six feet in error—Laplace's table being used in the calculation.

A second experiment at the same time, consisted in comparing three points within half a mile of the Pipehead dam, and within 100 feet of its level with the dam itself. The level of two of these points was given within two feet of the truth by a single observation, while the third which was not so well observed, owing to night coming on, was five feet in error.

A third experiment which has been frequently performed with the surveying class at the University, consists in taking the height of the gallery on the tower of Ormond College. This is 130 feet from the ground, and has been many times measured by instruments 1 and 2. The result has always been slightly below the truth, usually about 125 feet. I do not remember it ever having been below 120 or above 130.

On the 1st inst., having Mr. White's remarks in view, and having for other purposes to pay a visit to a place called Riverview, near the Yarra Glen Railway Station, I determined to make a careful test of the three barometers, and compare the result when fully worked out and all proper corrections applied, with the known difference of level by actual levelling. I therefore set the barograph going at the University, and carefully reading the three instruments at the Princes Bridge Railway Station, took them to Riverview, and read them as other engagements permitted, eight times in forty-eight hours. Thus I obtained twenty-four readings, which, when compared with the Princes Bridge readings, corrected by reference to the barograph and worked out by Laplace's table with instrumental and temperature corrections, gave the following results:—

| ANEROID No. 1. | ANEROID No. 2. | ANEROID No. 3. |
|----------------|----------------|----------------|
| 228 | 222 | 233·7 |
| 228 | 240·5 | 222·0 |
| 238 | 259 | 256·1 |
| 228 | 240·5 | 236·7 |
| 238 | 231·2 | 230·8 |
| 249 | 231·2 | 221·7 |
| 228 | 212·8 | 213·1 |
| 249 | 222 | 222·4 |
| Mean | 235·7 | 232·4 |
| | | 229·6 |



SECTION RETURNING

WATKIN BAROMETER RESULTS
SHOWN BY DOTTED LINE
RAILWAY LEVELS BY FULL LINE.